U. S. ARMY ENGINEER
GEODESY, INTELLIGENCE AND MAPPING RESEARCH AND DEVELOPMENT AGENCY
FORT BELVOIR, VIRGINIA

BRIEF AND EVALUATION

12 March 1962

STAT

CHANGE DETECTOR STUDIES
31 October 1961
Final Engineering Report

BRIEF -

Project Initiation. _____ started develop-   STAT
ment of the Change Detector several years ago with its own funds and con-
structed a breadboard model which demonstrated the feasibility of the
system. At the end of FY 61 GIMRADA applied _____ to assist in this   STAT
development with Modification No. 2, "Change Detection", to Contract No.
_____, "Extraction of Mapping Detail from Radar Photography".   STAT
This work was accomplished between 1 July and 30 September 1961. The
Final Report, Change Detector Studies, was completed 31 October 1961.
This report is final only in the sense that it covered the work accomplished
under the contract, including previous work done by Goodyear, and is
essentially a status report on the Change Detector for that date.

Change Detection. The Change Detector is a device that will automat-
ically register and compare two photographic images and read out the differ-
ences between them. When two transparencies of the same area are inserted
in the change detector, they are optically correlated to compensate for
differencies in scale, orientation, and displacement and to effect registra-
tion. After the two scenes have been properly registered, they are subjected
to the comparison process; each scene is examined in detail and a compari-
son is made that results in a signal proportional to the difference between
the two scenes. Some method must be found for handling unwanted changes
such as seasonal changes of vegetation and differences in shadows.

Correlation and Registration. Briefly, the _____ Change Detector   25X1
consists of two main parts: the registration or correlation system, and
the video difference detector. Goodyear has experimented with many types
of correlators in recent years and has concluded that the electromechanical
type is best suited for the change detector. For the search operation to
get approximate correlation, the comparison scene in the form of a trans-
parency is back-lighted and its image projected on the reference scene,
also a transparency. The light that is transmitted through the reference
scene is measured by a photo-multiplier. The correlation of the two
scenes is best when the maximum amount of light passes through the two

transparencies. Differences in displacement, orientation, and scale are
adjusted simultaneously by the movement of one scene, the rotation of op-
tical wedges, and the axial movement of the lenses. The matchpoint de-
tector stores the value of the match signal and servo positions that have
yielded the largest signal. After the search is completed, the servos re-
turn the equipment to the place where maximum light transmission was re-
corded, then the nutation process brings the scenes into exact correlation
for registration.

Comparison. When the two scenes are in registration, they must be
compared to determine if any changes are present.⬜⬜⬜⬜has experimented   STAT
with two types of detectors: the video difference detector, and the quo-
tient difference detector. As the reference and comparison scenes are
scanned simultaneously with the flying spot scanner, the video difference
detector compares the two images by measuring the difference in the corres-
ponding registered intensitites. The quotient difference detector compares
the two scenes by measuring the quotient of the corresponding intensities,
or in effect, the difference in the logarithms of the two intensities. The
quotient detector requires a negative reference scene and a positive com-
parison scene. The intensity quotient can be obtained by viewing one trans-
parency while the image of the second of opposite polarity is projected
through it.

With the video-difference detector, the information from each
scene is converted to video signals by synchronous scanning with a flying
spot scanner, which uses a split-optical system. The video signals ob-
tained from the two phototubes are amplified and subtracted and used to
modulate the intensity of a monitor CRT. The deflection of the monitor
CRT is synchronous with the deflection of the flying spot scanner so that
the scene geometry is maintained. The gain of the video channels is
controlled so that a no-difference condition results in a gray level,
which can be shown as a low contrast background on the CRT. A change in
either scene will appear as a very light or very dark area, depending on
the type of change and the scene in which it occurs. Both systems have
about the same capability as far as the ability to detect changes. The video
difference detector has been recommended for further development because
it requires no additional photographic processing of the two scenes (both
are positive or both negative), and it offers a greater potential for
electronic scene processing and noise rejection techniques.

EVALUATION -

The ⬜⬜⬜⬜Change Detector. The concept of change detection as   STAT
proposed by ⬜⬜⬜⬜is about as simple a method as could be devised. The   STAT
two scenes are brought into registration, then scanned simultaneously with
a flying spot scanner to detect the differences. This is just as simple as
aligning two transparencies and holding them up to a light source to note
the differences. It takes only a few seconds to get the scenes in regis-
tration, then the scene and changes can be presented on the monitor as the

transparencies are scanned. [   ] envisions a 2-screen monitor, so   STAT
the operator will be able to view both reference and comparison scenes,
view the comparison scene showing changes, make a flicker-type comparison,
enlarge areas for more detailed examination, or make adjustments for noise
rejection.

Proposals on change detection equipment from other companies
describe more complex equipment or procedures. One would include identi-
fication in the process, which is adding a much more difficult problem
which will not be solved until long after automatic change detection has
been accomplished and has no place in the process of change detection.
Another would divide the scene into small squares which would have to be
analyzed separately. Another proposal wanted funds to develop a type of
correlator which [   ] has already done. IBM is developing a Digital   STAT
Automatic Map Compilator, which has a change detection capability; however,
it uses very expensive, complex equipment and computers and presently takes
about 1½ hours to digitize and process the data to compare the two photos.
Although this time will undoubtedly be greatly reduced later, there are
extra time-consuming steps that are not necessary for change detection;
so it cannot be expected to keep up with the [   ] detector which takes   STAT
only a few seconds per frame.

Problems.

a. <u>Unwanted Changes</u>. Probably the major problem in the develop-
ment of the change detector is the unwanted changes caused by differences
in season (vegetative cover) and time of day (shadows). Other unwanted
variables are cloud cover, snow cover, improper exposure, and soil moisture
conditions. For maximum efficiency, the operator should be able to elimi-
nate from the display screen the effects of these unwanted changes. How-
ever, there is no method presently available to filter all these effects
from the display. It may be possible to adjust clipping levels to the
video signals to prevent some of these differences from being shown on
the screen.

b. <u>Registration</u>. [   ] has correlators which operate simul-   STAT
taneously in the x and y directions, but has not yet assembled one which
will operate 4 loops at once. No difficulties are anticipated, however.

c. <u>Coverage</u>. It will be virtually impossible to get frames from
the two rolls to line up exactly in either the x or y directions. In order
to compare an entire frame of new photography with the reference photos,
it may be necessary to correlate portions of it with 4 different frames
from the original photography. If stereo coverage is obtained, only the
alternate photos would need to be checked.

d. <u>Format</u>. It would be desirable for the change detector to
handle input film of several sizes--70 mm, 5-inch, and 9-inch. This would

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cause major problems in the optical system, however, and might add considerably to the dimensions of the facilitjy

Concept of Use. When photographic coverage is obtained of an area of intelligence interest, the photos will be examined very carefully to extract as much information as possible. If additional coverage is obtained later of same area, the points of greatest interest are likely to be those where changes have occurred since the first coverage was obtained. The change detector can quickly compare the two sets of photography, and present the changes on a monitor screen. Provision can be made to determine coordinates of the changes relative to the comparison photography and recording them on punch cards or tape. Then the interpreters can concentrate on studying and analyzing the changes which have been noted. Some initial interpretations can probably be made from the monitor screen on the change detector; however, the interpreter will undoubtedly need to refer back to the transparencies themselves for detailed study. There are several reasons why the interpreter would make his analysis using the transparencies directly: (a) the change detector is being designed as a screening device and not an interpretation facility, (b) the operator will not necessarily have to be a skilled interpreter, (c) the value of the change detector as a time-saving screening device will preclude its use for interpretation, which may be time consuming, and (d) there will be some loss of detail between the transparencies and the monitor screen. It is anticipated that the change detector can be used for radar and infrared coverage as well as for aerial photographs.

Need for a Change Detector. The capability exists to obtain such vast quantities of imagery that it could take months to interpret each day's coverage. Equipment is needed that will enable the interpreter to spend more time on actual interpretation rather than scanning and comparing areas which may be of little significance. A change detector would be a useful device which is within the state-of-the-art. For repeated photographic coverage of an area, the points of greatest intelligence interest are likely to be those where changes have occurred. If the photos can be screened to eliminate those on which there is no activity and the locations of changes on the remaining photos are furnished, the interpreters will know where to concentrate their analyses. A change detector of some type should be an important part of any photointerpretation facility.

For strategic intelligence a team of photointerpreters with the aid of a change detector could accomplish a specific job in a shorter time or it could analyze coverage of a much greater area within a specific time. In a tactical situation, it could more readily obtain the necessary information within the critical time limitations resulting from combat conditions.

Recommendations. It is recommended that funds be made available to complete the development of the _____ change detector. It can be fully developed in 18 months for approximately _____ An operational model   STAT
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could be delivered at that time. [   ] should continue development STAT
along the lines recommended in the subject report. Delivery of a useful
change detector within 18 months is considered to be a "low risk" project.
Some modifications can be made to fit the needs of a potential user.

The change detector should have the following capabilities:

a. Receive an input of two 100-foot rolls of 70mm trans-
parencies covering approximately the same geographical area.

b. After an initial alignment of the two rolls by the operator,
bring the two scenes into registration automatically.

c. Detect the differences between the two scenes with the
use of the video difference detector.

d. Present on a monitor screen the changes indicated in
white on a gray background scene of the area being scanned.

e. Minimize the presentation of unwanted differences on the
monitor screen.

f. Incorporate a method of quickly locating and recording
the changes with respect to the most recent set of imagery.

EVALUATED BY: [   ]   STAT
             Intelligence Division

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